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Use of Animal-operated Folding Perches by Rhesus Macaques (*Macaca mulatta*)

Matthew FSX Novak,* Caroline Kenney, Stephen J Suomi, and Gerald C Ruppenthal

Providing captive or laboratory animals with the best possible living conditions has led to many ideas about how caging environments can be enhanced and the animals' lives can be enriched. This study focused primarily on 2 issues: more efficient use of existing caging and providing animals with a measure of control over their environments. We designed a new spring-loaded folding perching apparatus that, when modified for size, could be added to almost any caging system. Experiment 1 measured usage by animals in standard laboratory caging for rhesus macaque monkeys (*Macaca mulatta*). Experiment 2 measured usage by this same species in social groups in a 5-acre outdoor–indoor field setting, where several other forms of enrichment were available to the animals. Results indicated that the folding perches were used in both environments. Animals quickly learned to fold down the devices to use as a place to perch, even in the presence of permanent fixed perches. The folding perches did not significantly affect existing behavioral repertoires, but they altered how the animal used the cage. Increased animal presence near folding perches during experiment 2 suggests that these devices actually were preferred. The preference results can only partially be explained by novelty. The folding perches afforded animals a measure of control over their immediate environment without interfering in research or animal care efforts. Including at least 1 folding perch per cage satisfies both the letter and the spirit of regulations on environmental enhancement for captive primates.

People who care for and work with animals in captivity have the very practical job of maximizing an animal's experience while juggling costs and resources. From the viewpoint of research scientists, the highest quality environments are needed to produce the best possible animals for modeling and understanding genetic, biologic, and behavioral processes. Although many of us would love to redesign our laboratories and accompanying facilities each time new enhancements and improvements are demonstrated, the cost of extensive modification to traditional animal caging and even to laboratory structure is prohibitive in many cases. In such instances, the best option is to incorporate innovative upgrades into scheduled redesigns and new architecture plans. In the short term, however, the challenge is to maximize animals' experiences within the limitation of existing laboratories and caging systems.

This effort has been accomplished by addressing the challenges of well-being from many directions. The driving forces behind this work range from regulatory upgrades[33-35] to increased understanding of the necessary and sufficient conditions to produce optimal animals with species-typical behavioral and physiologic repertoires.[16,17] Understanding based on behavioral observations is essential to long-term management of captive animals.

For nonhuman primates, research has shown that improvements in caging can be accomplished on the interior, as well as the exterior, of a caging system. Cage exterior additions can include mirrors;[2] various 'puzzle' feeders, which dispense a variety of food morsels such as nuts, fruit bits, and popped corn;[20] and plastic balls or other objects.[11] Television, video and audio recordings, and radios have also been promoted.[5,7,21,32]

Examples of changes inside the cage include enhancing visual and social contact between conspecifics;[8,10,24,30] cage size and location;[12] food delivery;[22] and variability or novelty in the diet, such as adding fruits and vegetables;[25] and adding to the interior of cages[15] such things as ropes, discarded water hoses, and wood pieces for chewing or gnawing.[23] Climbing structures and nesting boxes have been employed, both for scent marking in specific species and for nesting. Consistent with these improvements, devices such as perches have been mandated by the United States Department of Agriculture.[35]

To assess the effects of various changes to the environment, and their meaning to animals, one group proposed a framework to characterize, combine, and interpret the common themes emerging from these different approaches to managing captive animals.[16] In that review, the authors evaluated several different forms of enrichment according to usage, normalization of behavior, and abnormal behavior. Regardless of classification, several recommended enrichment items, such as food, serve only to alter an animal's behavior for limited periods of time each time they are provided. Other enrichment items are used extensively when first introduced but fail to provide long-term enhancement, because they are unchanging and quickly lose their novelty. Although the use of enrichment objects can be rotated according to a schedule (usually at cage-washing time), the novelty of even these items decreases over time.

Alternatively, giving animals a measure of control over their environments has been discussed.[1,35] Environmental control can take many forms, from allowing the animal an area where it can go to be out of sight of observers, to providing objects that an animal can destroy or objects whose makeup can be altered, such as added to or taken apart. In addition, researchers and animal management personnel can give animals choices that afford them control over various resources or socialization opportunities.[3,6] Research on this topic has shown that some animals prefer to have control over some aspects of the environment and that having this control may positively alter their behavioral repertoires to those more closely approximating species-typical behavior patterns.[36]

In response to these interests and concerns, we wanted to explore how control over some aspects of the environment

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Laboratory of Comparative Ethology, National Institute of Child Health and Human Development, NIH Animal Center, Poolesville, MD.
**Corresponding author. Email: novakm@mail.nih.gov*

could influence the lives of animals in captivity. We designed an animal-operated folding perch with tension springs that fold the sitting platform against the wall when not in use (Figure 1). Our initial goal was to establish that this novel possibility for enrichment was something animals would choose to interact with and use. This form of environmental control was not inherently related to food or social interactions, which have been studied and optimized in the past. Creative management personnel may be able, however, to use one or many perches in combination, to enhance both feeding and socialization experiences for the animal.

If macaque monkeys incorporate folding perches into their behavioral repertoire, then supplying one or more folding perches for individual animals may allow environmental control while minimizing the potential for conflict between individuals. Such conflict is often a risk when affording environmental control[1] in species in which dominance plays a role in social behavior. In addition, for some species and caging types, a folding perch actually may increase the functional floor space.

Methods and Materials

Animals. All of the research reported received prior approval from the National Institute of Child Health and Human Development's Animal Care and Use Committee and was conducted within the guidelines for ethical use of animals in United States Public Health Service policy as outlined in the *Guide for the Care and Use of Laboratory Animals*.[14] Animals used were bred and reared in the Laboratory of Comparative Ethology (Poolesville, MD).

Folding perch apparatus. The perch platform (the 'Ruperch'; Figure 1) was made of stainless steel and measured 25.5 cm × 15.0 cm and could be operated along a 90° arc. For this study, the base measured 29.0 cm × 5.0 cm and consisted of a rectangular metal plate with bolt holes drilled in it to which the hinge mechanism attached. A second metal plate of the same size with matching bolt holes functioned as a back plate for attaching the folding perch to caging. Each unit had 2 bolts for attaching the perch to the cage, and these bolts could be adjusted for the thickness of the wire mesh and other cage parts. Hinge tension was adjusted to allow the foldable platform to be pulled down to a horizontal position or folded vertically against the side of a cage without snapping into place. Once attached to the cage, folding perches were treated as part of the cage; no additional maintenance or special cleaning was required.

Experiment 1: Single- and pair-cage housing. Eleven rhesus macaques (*Macaca mulatta*) of various ages were available as subjects (Table 1). All animals were housed in the same room (8.84 m × 2.88 m); 4 of the 6 cages used to house animals already contained fixed perches. Housing arrangements were stable for at least 6 wk prior to the onset of this study, although 2 animals were removed from the room for sale during the experimental phase; only baseline and the first part of experimental data were available for these 2 animals. Folding perches were attached to the inner front wall of cages and did not obstruct the squeeze-back mechanisms when folded up. Regardless of housing type, 1 folding perch per animal, per cage, was mounted approximately 20 to 25 cm above the floor. The housing room was long and narrow, requiring observers to sit fairly close (0.75 to 1.0 m) to the focal subject's cage during observations. Therefore, animals were habituated to the presence of an observer for 4 wk prior to the onset of baseline data collection.

Behavioral data collection consisted of a slight modification to existing coding schemes typically used in the first author's laboratory[27] (Table 2). Observations of real-time behavior were

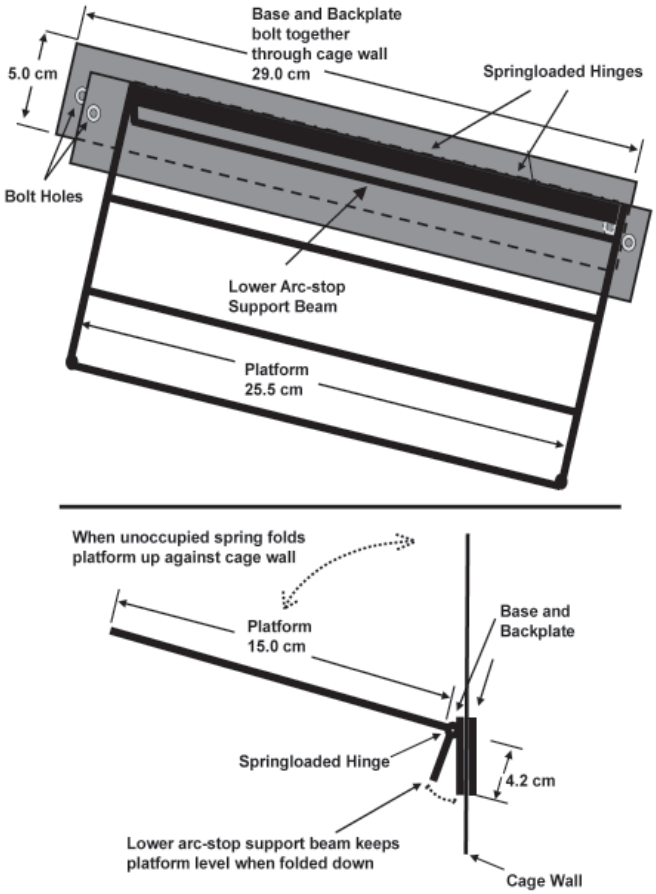

Figure 1. Top view and side view diagram of the basic form of a folding perch ('Ruperch'). Exact size and shape can depend on species requirements. The diameter of the stainless steel bars was 0.64 cm.

scored using a 4-digit exclusive and exhaustive coding scheme in which each digit can change independent of the other 3. Digit 1 encodes the role of focal subject in any interaction. Digit 2 encodes the behavior of the focal subject. Digits 3 and 4 recorded the use or nonuse of the folding perch and permanent perches, respectively. During the habituation phase, tests of reliability were conducted on the coding modifications to ensure high inter-rater reliability ($\kappa = 0.65$ across 3 consecutive test sessions on different monkeys, on at least 2 different days). Each animal was observed during a baseline phase prior to folding perch installation, 5 wk during its presence, and 2 more weeks after its removal, for a total of 9 wk.

Duration, frequency, and type of perch use were recorded for both permanent perches already in the home cage and for the folding perch during the portion of the study when it was installed. Data collection for each subject occurred for 5 min during morning (0900 to 1200), noon (1200 to 1500), and evening (1500 to 1800) time blocks twice a week across the 9-wk study period. The resulting data were used to address the following questions: First, would macaque monkeys use the folding perches? Second, how would they use them; to what degree would individual variation influence folding perch usage as opposed to permanent perch usage? And finally, would the folding perch influence behavior other than perch use?

Experiment 2: field enclosure. A total of 86 rhesus macaque monkeys (4 adult males, 32 adult females, 34 juveniles between 1 and 5 y of age, and 16 infants younger than 1 y) were used for this portion of the study. Macaques were free ranging. This enclosure included multiple tree houses and corncrib apparatuses

Table 1. Subject and caging characteristics

Subject	Gender	Housing	Age (y)	Weight (kg)	Cage size (m^3)[a]	No. of permanent perches present	Notes
1 (28)	F	Paired	19	7.4	8.6	1	Mother–daughter pair
2 (K27)	F		11	6.8			
3 (ZA23)	M	Paired	3	2.9	8.6	2	Sold during folding perch phase, before follow-up
4 (ZA60)	M		3	4.1			
5 (I14)	F	Single	12	6.4	4.3	1	Daughter to subject 1
6 (M25)	F	Paired	10	6.0	8.6	0	
7 (M38)	F		10	5.6			
8 (V14)	M	Paired	6	8.0	10.0	0	
9 (V31)	M		6	7.4			
10 (Z09)	M	Paired	4	4.9	8.6	1	
11 (Z42)	M		4	8.0			

F, female; M, male.
[a]4.3 m^3 = 0.66 m deep × 0.61 wide m × 0.89 m high; 8.6 m^3 = 0.66 m deep × 1.22 m wide × 0.89 m high; 10.0 m^3 = 0.89 m deep × 1.60 m wide × 1.17 m high.

Table 2. Focal subject coding system[27]

	Definition	Code
Digit 1:		
Type of interaction	Initiate with contact	0
	Initiate without contact	1
	Reciprocate with contact	2
	Reciprocate without contact	3
	No response or ignore with contact	4[a]
	No response or ignore without contact	5[a]
Digit 2:		
Focal behavior	Passive	0
	Exploring or grooming	1
	Withdraw	2
	Fear or disturb	3
	Dominance or submission	4
	Stereotypy, rock, huddle, self-clasp or self-bite	5
	Play	6
	Sex	7
	Aggression	8
	Eat or drink	9
Digit 3:		
Folding perch usage	No folding perch present (baseline and follow-up)	0
	Not using folding perch	1
	Using folding perch—sitting, standing, lying, walking on with perch properly folded down	2
	Other use of folding perch —touching, hanging from, as part of wall	3
Digit 4:		
Permanent perch usage	No perch present	0
	Not using perch	1
	Using perch—sitting, standing, lying, walking on	2
	Other use of perch—touching, hanging from, as part of wall	3

[a]Not included as behavior change for focal subject.

distributed throughout the outdoor area. The corncribs function both for enrichment and for protection from the elements. In addition, there are numerous trees, manmade climbing and perching apparatuses, and a pond with an island.

Attached to the enclosure is an indoor housing space, with enough room to house all the animals, which is available to the animals 24 h/d, 7 d/wk. The indoor portion consists of 4 nearly identical indoor habitats (5.7 m long × 2.7 m wide × 3.8 m high). One run, called a bachelor run, was separated from the other 3 by an opaque wall and was not used for the perch study. The remaining runs were side-by-side and separated by wire mesh and a walkway approximately 1 m wide. Each run was equally accessible from the outside through a single swinging door, with no access between runs inside the building. The folding perch usage study was conducted in the center run. Observations were made from the long end of the center run, opposite the animals' entrance from the field. The observer had full view of all 3 runs from their vantage point, and the 2 runs on either side served as controls from which instantaneous scans of the number of animals present were collected to compare with the number of animals present in the enhanced run.

Due to the size of the outdoor field enclosure and the number of individuals, the probability of any individual animal using a perch or even being inside during any single observation period was low. Therefore, data were collected using a focal perch sampling methodology. During baseline, the 3 runs were

unchanged. In the folding perch condition, 10 folding perches were evenly distributed around the center run. Five were mounted in the bottom half of the space approximately 1.5 m from the floor, and 5 were mounted in the top half of the space approximately 2.5 m from the floor. In the interior of the center run, 5 permanent perches (0.5 m × 1.0 m) were already in place; use of these perches also was recorded. In addition, suspended swing apparatuses and feed boxes inside the enclosure could be used for perching, but their use was not recorded.

Animals had considerable experience with observers, particularly in the outdoor enclosure. However, they were further habituated to the presence of an observer inside the building daily for 2 wk prior to baseline data collection. Baseline data were collected for 2 wk. Each day, animals were allowed to habituate to the presence of the observer for 15 min prior to the first observation. Just as in experiment 1, data collection occurred during morning, noon, and evening time blocks, twice a week. After the baseline period, the folding perches were affixed to the enclosure for 5.5 wk. For experiment 2, follow-up data were not collected after the folding perches were removed. The entire study was conducted on nonrainy days during December and January, and no extreme weather occurred that would keep the animals inside during the study.

Two types of data were collected. First, duration of use of all folding perches collectively, versus duration of use of all previously existing permanent perches, was recorded. As in experiment 1, our interest was to document use of permanent perches versus the more novel folding perch with which an animal can exercise some control over its environment. Second, instantaneous scans of each of the 3 indoor runs were conducted every 5 min for a total of 10 each session. If animals preferred the folding perches, more would be expected to remain near the folding perches than in the 2 control runs.

For both experiments, data were analyze using SPSS 14.0 statistical software (SPSS, Chicago, IL). Repeated measures analysis of variance with Greenhouse-Geisser correction for violation of parametric assumptions, one-sample *t* tests, and dependent groups *t* tests were used to determine statistical significance. Criterion for significance was set at 0.05.

Results

Experiment 1. Each animal was observed 3 times daily, 2 d each week, for the duration of the study. Frequency and duration of perch use data were averaged for each subject and then analyzed by comparing pretest, test, and posttest by using repeated measures analysis of variance. The presence or absence of the folding perch devices had no significant effect on the rates of behavior change (digits 1 and 2 collapsed across digits 3 and 4; Greenhouse–Geisser F[1.4, 11.2] = 0.56, $P > 0.05$), and there were only minor, nonsignificant changes in specific behaviors and types of behavioral interactions. However, use of the folding perches was quickly incorporated into existing behavioral repertoires. Within the first hour of exposure to the folding perches, 10 of the 11 animals were observed using the perches. By the second day, all 11 animals had pulled down the folding perch and sat on it at least once. Collectively, a single-sample *t* test across the 4 wk of data collection showed significant use of the perches ($t[10] = 4.715$, $P < 0.001$; H_0 = no usage, Figure 2), but there was considerable variation between and within individuals (Figure 3). Habituation to the devices occurred in only some animals. Furthermore, uses of the perch for reasons other than perching, such as holding the perch down but sitting in another location, attempting to fold it up to pinch itself or another animal, and repeated stereotypic folding down and releasing, also were quite rare.

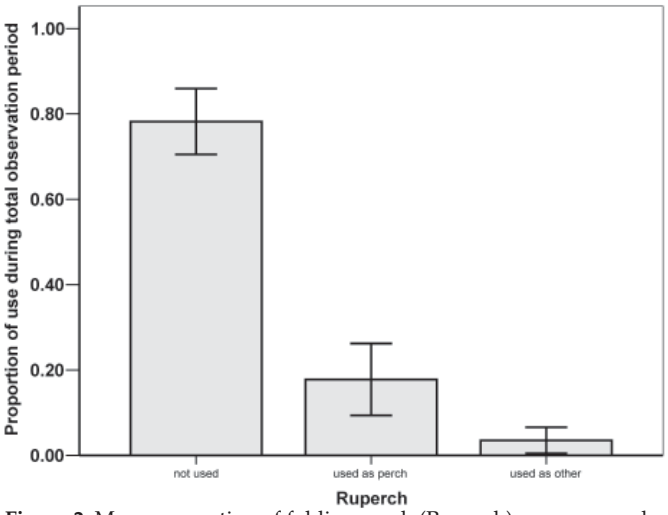

Figure 2. Mean proportion of folding perch (Ruperch) use across subjects. Error bars represent the 95% confidence intervals (1.96[standard error of the mean]).

The presence of folding perches affected how the animals used permanent perches already in the cage (n = 7, Figure 4). Repeated-measures analysis of variance of digits 3 and 4 of the behavior code collapsed across the first 2 digits showed a nonsignificant change in permanent perch use while the folding perches were on the cage (overall Greenhouse–Geisser F[1.15, 4.62] = 2.72, $P = 0.17$). However, use of permanent perches increased after the folding perches were removed, such that perch use after removal of the folding perches was significantly higher than during baseline (pairwise contrast F[1,4] = 13.23, $P < 0.05$).

Experiment 2: field enclosure. Although experiment 1 clearly demonstrates that adult rhesus monkeys will use folding perches, a complementary question that might be asked is "Do rhesus monkeys prefer folding perches to other forms of enrichment?" In terms of preference, 2 possible interpretations explain the results obtained during experiment 1. First, usage of the folding perches show a preference for them relative to other experiences afforded them. A second alternative is that folding perch usage was not a function of preference but of being less objectionable than the alternatives. For example, a cup of hot chocolate might be preferred after a day in the snow but only endured by someone with no other options for a beverage after riding a bicycle in the hot summer sun.

Experiment 2 investigated usage in a second context and some aspects of preference in the form of both usage and attractiveness. Folding perches were affixed to the indoor portion of a large (5-acre) field enclosure. This enclosure contained greater variety of monkeys from infants to adults and more enrichment opportunities than the standard indoor laboratory caging in experiment 1. Experiment 2 also considered preference as opposed to usage. For preference, use alone may not be the best indicator. If choice is the central mechanism of enrichment involving control, then usage alone may not be an indicator of enrichment. Choosing not to use may be equally as enriching as usage itself. Therefore additional aspects need to be studied; to that end, we evaluated both usage and animal proximity to the areas in which the perches were affixed.

The duration of perch use by one or more monkeys was recorded on 17 separate occasions across the 5.5-wk experimental phase (Permanent perch: n = 8; Total duration, 3.23 h; folding perches, n = 9; total duration, 3.51 h). Competing stimuli var-

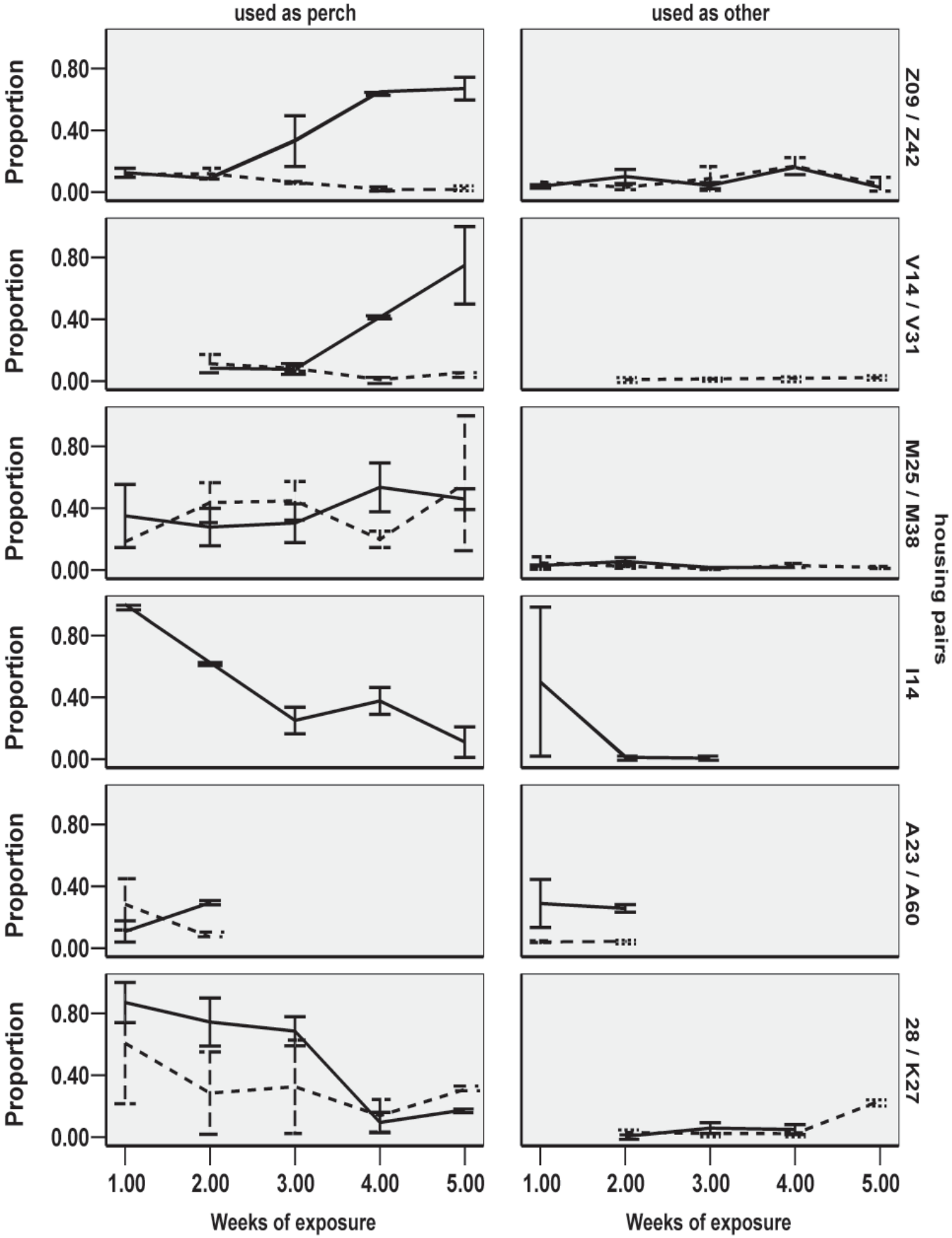

Figure 3. Mean proportion of observed time for typical (left) and other (right) use of individual folding perches by pair-housed rhesus macaque monkeys across 5-wk exposure period. For each pair listed (right axis), the first animal is represented by the solid line, and second by the broken line. Error bars represent ±1 standard error of the mean.

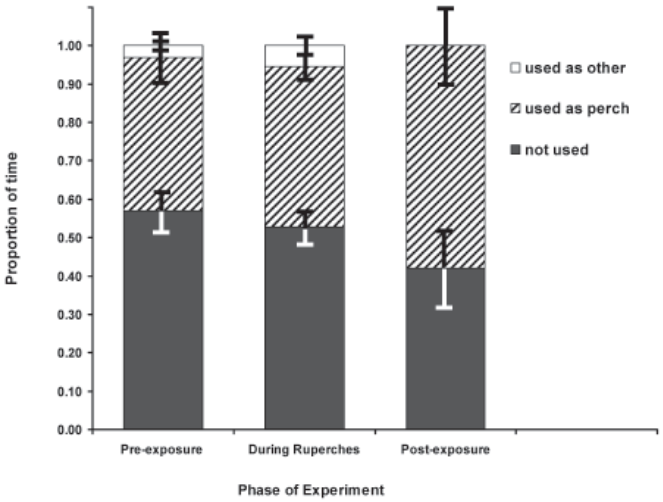

Figure 4. Mean proportion of observed time permanent perches used during baseline (pre-exposure), folding perch exposure (during Ruperches), and follow-up (post-exposure) phases of experiment. Error bars represent ±1 standard error of the mean.

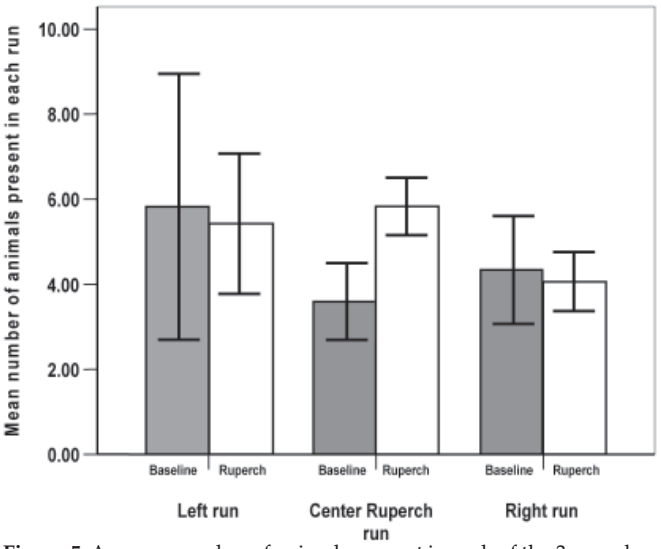

Figure 5. Average number of animals present in each of the 3 runs during baseline and later when folding perches (Ruperches) were affixed to the center run. Data represent 60 simultaneous scans of each enclosure across the final week of baseline phase and 60 simultaneous scans of each enclosure in each of 4 wk of exposure. Error bars represent the 95% confidence intervals (1.96[standard error of the mean]).

ied considerably from day to day, but collectively the subjects exhibited significant use of the folding perches (mean, 31.1% of observation time; standard error, 9.35; H_0 = no usage, $t[8] = 3.33$, $P < 0.05$). When compared with the percentage of time the macaques used permanent perches, use did not differ between the 2 types of perch (permanent perches: mean, 32.4%; standard error, 10.93; $t[15] = -0.87$, $P > 0.05$). In addition, duration of folding perch use did not vary according to time of day ($P > 0.05$). These data suggest that despite the novelty of the devices, the animals relate to the folding perches no differently than to the permanently fixed perches. Furthermore, animals showed no differences in preference for any of the runs during baseline. However, the center run, in which the folding perches were located, was the least frequented during the baseline phase (Figure 5).

In addition to use of the folding perches, the number of animals in the center run increased significantly ($t[9] = 5.16$, $P < 0.001$) between the baseline and folding perch phases, by using scan order within the observation session as the repeated measure to control for any situational effects related to observer presence. Independent-groups analysis showed the same effect (data not shown). Consistent with a preference hypothesis, once folding perches were affixed to the center run, animals were in the center run more often, but differences from comparison with the other runs were not statistically significant. Despite this significant increase in the number of animals present in response to folding perches, Figure 6 shows a trend toward habituation of the center run across the 11 sessions of data collection during the folding perch exposure phase of data collection. We have no explanation for the peaks in animal numbers observed during sessions 2 and 8.

Discussion

Our results indicate that the folding perch indeed was used by rhesus monkeys. Although the presence of the folding perches in the cage did not have a significant effect on the overall behavioral repertoires of individuals, the frequency of folding perch use and how it affected permanent perch use varied with individual animals. The data from the field enclosure are consistent with the argument that folding perches are preferred. However, young rhesus monkeys, juveniles and infants of both sexes, used the folding perches at a level not different from that for standard perches permanently affixed to their cages, even though presumably more enriching stimuli and opportunities for social interactions were available.

In experiment 1, use of the folding perches did not have a significant effect on the overall behavioral repertoire of individual animals. However for some animals, there was a change in the way they used the caging environment. This change first occurred in relation to presentation of the novel folding perches and persisted beyond the experimental phase, to when folding perches were no longer present.

Several sources of variance may have contributed to the size of individual differences observed among animals in experiment 1. For example, those with no permanent perch in their cage (V31–V14 and M25–M38) did use the folding perch but spent most of their time not using it. Pair A23–A60 had 2 permanent perches, whereas I14 and pairs K27–K28 and Z09–Z42 each had only 1 permanent perch in their cages. Further, I14 was singly caged during this experiment, whereas the other animals were pair-housed. Dominance relationships between the pair-housed animals may have affected access to the folding perches. This interference presumably would keep one of the animals from interacting as much as they otherwise would choose to interact. Likely the effect of dominance on our data would have been to make the usage data even more significant. However, in this experiment folding perches were available for each animal, lessening the likelihood of a dominance effect that suppressed usage of the folding perches in this study. In addition to these factors, sex differences and cage size (including cage size relative to animal size) might have contributed to the individual differences detected. Any of these factors may have contributed to behavior patterns at various times throughout the experiment.

One explanation for the effects observed is that the folding perches increased overall movement in the cage. Although the folding perch increased overall perch usage (of either the permanent perch or the folding perch), the frequency of behavior changes or in other types of behavior exhibited did not increase during the observation period.

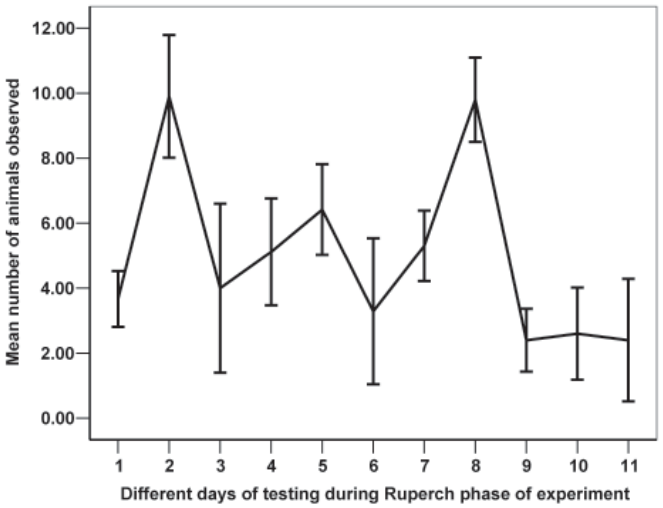

Figure 6. Variation in the number of animals observed in center folding perch run across test sessions during folding perch (Ruperch) exposure phase. Error bars represent the 95% confidence intervals (1.96[standard error of the mean]).

We were concerned that the novelty of the folding perch would decrease as exposure time increased, but this was not the case. For some animals, usage actually increased over the 5-wk period, suggesting that the folding perch would continue to be used throughout its time in the housing environment. Since this study, folding perches have become a continuous fixture in some of our large social breeding group cages, and considerable use of these devices has continued during the subsequent months. Even large adult males have used folding perches, a phenomenon that did occur during data collection in the field enclosure experiment. None of the folding perches failed during the 9.5 wk they were continuously attached, and even perches with adult males and females (whose weight of greater than 10 kg exceeded that for which the folding perches were designed) in a large group setting underwent 6 mo of continuous use before a couple of the tension springs began to loosen. This information was used to improve the durability of later versions of the folding perches, however, each folding perch device should ideally be tailored to the size and tension requirements of the age and species for which they will be typically used.

One possible reason for folding perch usage is not that the perches themselves were preferred but that the environment was impoverished and therefore any change would be preferred. Data from the field enclosure, however, support a preference argument. The animals had other indoor enclosures, 5 acres with a pond outdoors, and numerous climbing and perching devices as alternatives, and yet there was an increase in the number of animals in and around the indoor run with folding perches. In both experiments, folding perch usage across animals declined as time of exposure increased. However, declines were not dramatic and, in experiment 1, some animals actually increased their interactions with the folding perch. Therefore, novelty accounts for some, but not all, of the increased proximity.

One concern about the folding aspect of the folding perch apparatus involves alternative uses. Just as with any apparatus afforded animals, how they use them may or may not be related to the researcher's or colony manager's intention. Therefore, data were collected both when the device was being used as a perch and when it was being used for some other purpose. Other usage was quite rare and usually consisted of inadvertent contact. Furthermore, only 1 brief instance of pinching has been seen and occurred when a young juvenile macaque approached and grabbed both the top outward edge of the platform and the lower arc stop support (which stops the perch when it gets to 90°) at the same time. The body weight of the animal pulled the platform down, briefly trapping the other hand. The animal quickly freed its hand, and no injury resulted.

There are at least 2 potential benefits to adding folding perches or converting to their use in caging for nonhuman primates. The first includes increasing the amount of floor space available for other activities. In some current caging configurations, the area of the cage may not be typically used by some species or sizes of animals. Replacing the fixed perch with a folding perch that folds against the wall when not in use creates a more functional use of this area. In addition, for some current caging arrangements, installing folding perches may allow colony mangers more flexibility and variety in how cages can be modified. When using squeeze-back restraints, however, one must be careful to avoid obstructing the mechanism; the large caging environment of experiment 2 lacked this potential problem. In experiment 1, the folding perches were mounted on the front guillotine doors, where they neither obstructed the squeeze-back mechanism nor operation of the door itself. Mounting the folding perches on the squeeze back could have been an option. But for these cages, mounting the folding perches on the side of the cage would have required modification of the squeeze back so that the lower arc stop would not obstruct squeeze-back movement. In addition, the front and back mounting locations might cause obstruction if the animal refuses to move from the perch during a squeeze-back restraint, although this situation has not yet occurred.

At least in rhesus macaques from this study, folding perches have little effect on behavioral repertoires, showing that minimal additional conflict or competition arose during this form of enrichment. The lack of change in behavioral repertoires, however, most likely is a function of the particular animals used in these experiments. In the field enclosure, there were very low levels of abnormal or nonspecies-typical behavior. In addition, the room used for animals studied in laboratory caging was selected randomly; therefore our research subjects were not candidates for behavioral modification or considered to be particularly poorly enriched prior to participation in this study. Changes in behavioral repertoire might be more likely in other groups of animals.

The second potential benefit of folding perches is related to the idea of choice and giving captive animals some measure of control over their environment. Supplying one or many folding perches for individual animals may allow environmental control without limiting access for either data collection or animal care. Psychologic literature has a long history of demonstrating positive outcomes in organisms that have control of their environment relative to those without control.[4,9,18,19,26,31,37] In recent years, giving animals control over their environment has been addressed in the literature and has been offered as an important and characteristic component of enrichment experiences.[29] At its simplest, the gradual or rapid destruction of enrichment items has been offered as a source of control that is afforded to individuals.[13,36]

Sambrook and Buchanan-Smith[29] identified a classification system for grades of controllability and concluded that some animals interact more with forms of enrichment over which they have more control than forms over which they have less control. Usage as a measure of preference, however, needs further consideration. In measuring enrichment, use usually is characterized as evidence of positive effect. However, when

providing animals with alternatives in which they can choose to use or not, then usage may underestimate the enriching quality of the device or experience. Choosing to interact with enhancements may be enriching; choosing not to interact with enhancements may be enriching also. The importance, of course, is having choice. Consistent with this idea, significant benefits emerged when passive avoidance was the manner in which control was expressed.[28]

Our data show that, at least for rhesus macaque monkeys, folding perches may be valuable to both psychologic well-being and colony infrastructure. This demonstration, however, generates additional questions that need to be addressed. First, the findings should be tested in other species and other facilities. We evaluated folding perch usage in 2 different populations within our lab. The first and last coauthors made some preliminary anecdotal observation on other rhesus monkeys at the Pittsburgh Development Center (Magee Women's Hospital, Pittsburgh, PA) during device development, but a systematic study was not performed. Therefore, further replication is necessary. A second issue is whether use of these devices affects abnormal behavior. The present study was specifically designed to test usage. Although our data did not reveal a change in behavioral repertoire in response to availability of folding perches in the cage, the type of behavior and method of data collection would have been different had the goal been to document the specific effect (additions or subtractions) on any existing abnormal behaviors. Third, further research could collect more detailed information about specific abnormal behaviors to combine usage information, such as in this study (which is one of the evaluation metrics), with the 2 other metrics of normalization of behavior and abnormal behavior. Finally, the folding perches primarily were intended for use by individual animals, however, other applications could be explored. For example, arranging several devices side by side horizontally or vertically in a species-appropriate stagger may create steps for monkeys to transverse between adjacent areas of the cage. Alternatively, the spacing between or among perches can be used to affect the spatial distribution of animals. Because these devices are adjustable, they can be used to encourage grouping at one time of the year and discourage grouping at other times. The effectiveness of different arrangements needs systematic study, but for creative colony or enrichment personnel, folding perches likely provide a valuable tool to modify, manipulate, and enhance existing caging environments in which nonhuman primates live.

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References

1. **American Society of Primatologists** [Internet]. c1995–2002. Response to the USDA draft policy on environment enhancement for nonhuman primates. [cited 2006 December 1]. Available from: http://www.asp.org/society/resolutions/Usda_response.html.
2. **Anderson JR.** 1984. Monkeys with mirrors: some questions for primate psychology. Int J Primatol **5:**81–98.
3. **Andrews MW, Rosenblum LA.** 2002. Response patterns of bonnet macaques following up to 75 weeks of continuous access to social, video, and food rewards. Am J Primatol **57:**213–218.
4. **Bandura A.** 1977. Self-efficacy: towards a unifying theory of behavior change. Psychol Rev **84:**191–215.
5. **Bloomsmith MA, Keeling ME, Lambeth SP.** 1990. Videotapes: environmental enrichment for singly housed chimpanzees. Lab Anim **19:**42–46.
6. **Bovet D, Washburn DA.** 2003. Rhesus macaques (*Macaca mulatta*) categorize unkown conspecifics according to their dominance relations. J Comp Psychol **117:**400–415.
7. **Brent L, Stone AM.** 1996. Long-term use of television, balls, and mirrors as enrichment for paired and singly caged chimpanzees. Am J Primatol **39:**139–145.
8. **Butler RA.** 1958. The differential effect of visual and auditory incentives on the performance of monkeys. Am J Psychol **71:**591–593.
9. **Coleman K, Tully LA, McMillan J.** 2005. Temperament correlates with training success in adult rhesus macaques. Am J Primatol **65:**63–71.
10. **Crockett CM, Bellanca RU, Bowers CI, Bowden DM.** 1997. Grooming contact bars provide social contact for individually caged laboratory macaques. Contemp Top Lab Anim Sci **36:**53–60.
11. **Crockett CM, Bellanca RU, Heffernan KS, Ronan DA, Bonn WF.** 2001. Puzzle ball foraging for laboratory monkeys. Lab Primate News **40:**6–11.
12. **Crockett CM, Shimoji M, Bowdon M.** 2000. Behavior, appetite, and urinary cortisol response by adult female pigtailed macaques to cage size, cage level, room change, and ketamine sedation. Am J Primatol **52:**63–80.
13. **Fouts RS.** 1998. On the psychological well-being of chimpanzees. J Appl Anim Welf Sci **1:**65–73.
14. **Lambeth SP, Bloomsmith MA.** 1992. Mirrors as enrichment for the captive chimpanzee (*Pan troglodytes*). Lab Anim Sci **42:**261–266.
15. **Lutz CK, Novak MA.** 2005. Environmental enhancement for nonhuman primates: theory and application. ILAR J **46:**178–191.
16. **Markowitz H, Line S.** 1989. Primate research models and environmental enrichment. In: Segal EF, editor. Housing, care, and psychological well-being in captive and laboratory primates. Park Ridge (NJ): Noyes Publications. p 203–212.
17. **Mineka S, Gunnar M, Champoux M.** 1986. Control and early socioemotional development: infant rhesus monkeys reared in controllable versus uncontrollable environments. Child Dev **57:**1241–1256.
18. **Mineka S, Henderson RW.** 1985. Controllability and predictability in acquired motivation. Annual Rev Psychol **26:**495–529.
19. **National Research Council.** 1996. Guide for the care and use of laboratory animals. Washington (DC): National Academy Press.
20. **Novak MA, Kinsey JH, Jorgensen MJ, Hanzen TJ.** 1998. Effects of puzzle feeders on pathological behavior in individually housed rhesus monkeys. Am J Primatol **46:**213–227.
21. **Platt DM, Novak MA.** 1997. Videostimulationas enrichment for captive rhesus monkeys (*Macaca mulatta*). Appl Anim Behav Sci **52:**139–155.
22. **Reinhardt V.** 1993. Using the mesh ceiling as a food puzzle to encourage foraging behavior in caged rhesus macaques *(Macaca mulatta*). Anim Welf **22:**165–172.
23. **Reinhardt V.** 1997. The Wisconsin gnawing stick. Anim Welf Info Center Newsl **7:**11–12.
24. **Reinhardt V.** 2002. Addressing the social needs of macaques used for research. Lab Prim Newsl **41:**7–10
25. **Roberts RL, Roytburd LA, Newman JD.** 1999. Puzzle feeders and gum feeders as environmental enrichment for common marmosets. Contemp Top Lab Anim Sci **38:**27–31.
26. **Roma PG, Champoux M, Suomi SJ.** 2006. Environmental control, social context and individual differences in behavioral and cortisol responses to novelty in infant rhesus monkeys. Child Dev **77:**118–131.

27. **Ruppenthal GC, Sackett GP.** 1992. Research protocol and technicians manual: a guide to the care, feeding, and evaluation of infant monkeys, 2nd ed. Seattle: Infant Primate Research Laboratory, University of Washington.
28. **Rush DK, Mineka S, Suomi SJ.** 1982. The effects of control and lack of control on active and passive avoidance in rhesus monkeys. Behav Res Ther **20:**135–152.
29. **Sambrook TD, Buchanan-Smith HM.** 1997. Control and complexity in novel object enrichment. Anim Welf **6:**207–216.
30. **Schapiro SJ, Bloomsmith MA.** 1994. Behavioral effects of enrichiment on pair-housed juvenile rhesus monkeys. Am J Primatol **32:**159–170.
31. **Seligman MEP.** 1975. Learned helplessness: on development, depression, and death. San Francisco: WH Freeman.
32. **Swartz KH, Rosenblum LA**. 1980. Operant conditioning by bonnet macaques for color videotape recordings of social stimuli. Anim Learn Behav **8:**311–321.
33. **United States Department of Agriculture.** 1999. Animal welfare: draft policy on environment enhancement for nonhuman primates. Fed Reg **64:**38145–38150.
34. **United States Department of Agriculture.** 2006. Environmental enrichment for nonhuman primates resource guide. Adams KM, editor. Baltimore (MD): United States Department of Agriculture.
35. **United States Department of Agriculture, Animal and Plant Health Inspection Service.** 1991. Animal welfare standards: final rules. Fed Reg **55:**6426–6505.
36. **Videan EN, Fritz J, Schwandt ML, Smith HF, Howell S.** 2005. Controllability in environmental enrichment for captive chimpanzees (*Pan Troglodytes*). J Appl Anim Welf Sci **8:**117–130.
37. **White RW.** 1959. Motivation reconsidered: the concept of competence. Psychol Rev **66:**297–310.